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Inevitable Environmental Degradation due to Textile Waste in Bangladesh: Is there Really a Solution?

*Jahid M M Islam[1], Md. Mahbubur R. Bhuiyan[2] and Mubarak A Khan[1]**

[1]Institute of Radiation and Polymer Technology, Bangladesh Atomic Energy Commission, Dhaka-1000, Bangladesh

[2]Echotex Limited, Kaliakoir, Gazipur, Bangladesh

ABSTRACT
Experiments revealed that proper ionizing radiation can completely detoxify the waste water and sludge to water soluble non-toxic form and the resulting residues can be used as liquid fertilizer as dyes are mostly stable nitrogenous compound and their degradation leads to produce water soluble nitrogenous salts which are readily available for uptaking by plants. Besides, sludge produced by the chemical or biological ETP contains minerals and biomasses that enrich soil fertility. Field trials showed excellent plant growth promotion without any adverse effect where raw sludge showed significant toxicity. Grown plants were subjected for toxicity, heavy metal content test etc. and were found safe for human consumption. Animals (rabbit) fed by this plants (grown in the treated sludge and effluent containing soil) showed no sign of complexity at any phase of life or during pregnancy. Besides, eco-brick and composite materials were also produced from sludge which can be employed as an alternative of conventional construction material. Possibility of reuse of the treated effluent in the dyeing plants is another great finding. All this experiments suggested that employment of ionizing radiation for textile effluent treatment is very potential to protect environment from this devastating pollution.

Keywords: Textile sludge, Gamma radiation, Detoxification, field trial.

*Corresponding author: Email-makhan.inst@gmail.com

INTRODUCTION
Environmental pollution has become a significant world concern. The main causes of this contamination are industries, which generate and deliver to the environment waste products often without any treatment. Most of these contaminants biodegrade very slowly, becoming dangerous for people, plants and animals. Damage to human health related to improper treatment of residues has led to strict environmental protection laws and consequently the need for research in the treatment of effluents [1-3] and sludge.

The variables involved in the environment's recuperation are numerous, mainly by the great variety of chemical compounds and raw materials used by industry. The most complicated industrial effluents are organic compounds, especially synthetic agents. Their degradation is difficult using conventional methods. The quality and quantity of industrial wastes change depending on the material used, and related processing technique. The aim of the conventional techniques employed is to reduce the volume and toxicity of the effluents but even with treatment, inevitably some waste still remains. Textile industries consume a large amount of water and use toxic products in its processes. Consequently, they produce and release large volumes of effluents, which after treatment, generate great amount of sludge. The final disposal of this sludge remains a challenge, as it contains a lot of toxic materials and depositing them in the usual ways will deteriorate the environment. Biological treatment such as activated sludge has been the choice of the majority of the facilities [4]. However, this process generates a great quantity of sludge [5] that is basically formed by the excess of biomass and substances that were not degraded during the biological treatment.

The aim of this research is to undertake a thorough study to discover if at the end of ionization processing of textile sludge; it can be used as a bio-fertilizer. Not only is this an attractive means of treating what is essentially a waste product, but recycling it to be used as fertilizer means we have achieved the state of zero waste production.

EXPERIMENTAL

Sample Collection
The combined textile sludge was collected from the Eco Tex textile industry, Kaliakoir, Gazipur. Then it was packed in small polybags (3 Kg/bag) and were sealed.

Gamma Irradiation of the Textile Sludge

The samples were irradiated by cobalt-60 gamma radiation source at different radiation doses (5KGy, 10KGy, 15KGy, 20KGy and 30KGy). The dose rate was 4.5 kGy/h.

Characterizations of Raw & Irradiated Sludge
Both raw and irradiated sludge were characterized by the means of pH, conductivity, TDS (total dissolved solids) and COD (Chemical oxygen demand) as well as solubility and biodegradability. All these parameters were measured with standard chemical methods.

* Corresponding author. Tel.: +88-01819252292
E-mail address: makhan.inst@gmail.com

Solubility Test of Raw and Irradiated Sludge

Sludge was dried in an oven for 12 hours at a temperature of 105°C. After cooling grinded samples were kept in oven and dried at same temperature for several hours for the completion of drying. Then samples were sieved with a 0.5µm sieve. The resulting samples were weighted in a test tube and excess amount of distilled water was added. Samples were subjected to vortex and then kept for one hour. They were finally centrifuged to precipitate the insoluble portions and weighted after drying. Solubility was calculated in percentage.

Biodegradability Test

Garden soil was prepared my mixing with sludge samples at several ratios. The resulting samples were collected at different time interval, mixed with distilled water and kept for settle down. The grain patterns of the samples were compared and the biodegradability was estimated.

Seed Germination Test

Soil bed for germination was prepared using both treated and untreated sludge and then placed in Petri dishes. 30 *Basella alba* seeds were planted in each Petri dish, and left in an area were adequate amount of air and sunshine could be obtained. Seed germination was observed and counted after five days. The studies were triplicated for each samples and average value was taken.

Field trial

The experimental field was divided in three plots of equal areas, each of them were 9 sq. feet (3ft × 3 ft.). Then the irradiated (by 15kGy) sludge and raw sludge was mixed with the garden soil in 1:2 ratio. Plots having only garden soil served as control. The vegetables were sowed into the prepared plots after three days. No additional fertilizer was used.

Measurement of Plant Morphological Characteristics

Plant heights, width & number of leaves were observed for ten weeks consecutively. The plant heights were measured from soil surface to the top of the main plant stem. In order to measure the number of leaves, every visible leaves of each plants were counted, including the tips of new leaves just beginning to emerge.

Elemental Analysis

The samples were washed with the distilled water to remove the dust particles. After that the samples were dried at 100°C for 6-8 hours. Dried samples were then ground into a fine powder using a mortar and stored in a polythene container until used for the elemental analysis by 3MV Tandem Accelerator. Before analysis sample pellets were prepared using pellet preparation equipment. For the preparation of pellet 1.5 mg sample were taken.

RESULTS AND DISCUSSIONS

Effect of Gamma Ray on Solubility of Sludge

Sludge of the textile mostly contains metal hydrated oxides and organic compounds. Most of these compounds breakdown in simpler molecules when irradiated. So, the solubility of sludge increases. It was found that almost 17.70% of sludge became soluble at 15 kGy dose of gamma radiation.

Table -1: Effect of gamma radiation on solubility of sludge

Samples	Raw sludge	5kGy	10kGy	15kGy	20kGy	30kGy
Percentages of solubility	6.30%	8.80%	6.50%	17.70%	8.30%	11.30%

Biodegradability Test

Biodegradability test of different dose of irradiated sludge and raw sludge is carried out four weeks consecutively by comparing the morphology of pure soil. After 4 weeks, it was observed that 15KGy irradiated sludge was miscible in pure soil completely whereas untreated sludge showed no notable miscibility. These results suggested that, the biodegradability of sludge can me reduced up to 4 weeks by gamma radiation treatment while untreated sludge takes around one year for biodegradation.

Chemical Oxygen Demand

The chemical oxygen demand analysis for sludge samples (1g/500mL) showed very interesting result. The highest COD at 20kGy with 26mg/L and lowest COD at raw sludge with 13mg/L were found. It can be assumed that there was an increase in COD with radiation occurred because the interactions (coagulation) between the minerals and organic matters decreased with radiation which led to increase available organic substances for titration. This phenomena was also justified by the increased biodegradability.

Germination Test

The rate of seed germination in the soil preparations is given in table 2. Soil prepared with 15kGy irradiated sludge showed same germination rate as plain soil (73%). The result for raw sludge showed poor germination rate within the same time period which indicated the toxic effect of untreated sludge.

Table-2: Rate of germination of irradiated sludge, raw sludge and pure soil

Sample ID	Seeds germinated from 30 seeds	Percentages (%)
Soil	22	73%
Raw sludge	12	40%
5KGy irradiated sludge	15	50%
10KGy irradiated	13	43%

sludge		
15KGy irradiated sludge	22	73%
20KGy irradiated sludge	21	70%
30KGy irradiated sludge	16	53%

Field trial observation

Irradiated sludge showed better crop growth compared to pure garden soil in all aspects. Although the weight and height of crops grown in raw sludge also showed better results, but was obvious toxicity in the plants since the leaves were showing brown spots and discoloring.

The mixture of 15KGy irradiated sludge & soil lead to plants with green colored leafs, maximum growth and maximum diameter. Other hand, the plants of pure soil showed low growth rate as no fertilizer was used. So treated sludge was uptaked by plants as fertilizer without any sign of toxicity.

Figure-1: Growth Amaranthus Viridis (Local Name: Danta Shak) Grown in Soil, Raw Sludge and Irradiated Sludge mixed soil preparations

Heavy Metal Detection Test

Plants grown in different soil preparation were subjected to heavy metal content test (table -3). Heavy metals were detected in the samples but they were within the acceptable limits. No significant metal content difference was found in the plants grown in plain soil and the plants grown in sludge preparations. As heavy metal containing dyes are banned for use in textile industry, these results were quite expected and justified.

Table-3: Comparison of heavy metal content of plants grown in different soil preparation

Conc (ppm)	Ti	V	Cr	Co	Ni	Cu	Zn
Raw Sludge	587.6	424.6	241.6	1413	0	0	80.42
Irradiated sludge	1652	840.8	1007	2042	181.9	48.46	120
Soil	8388	306.1	462.5	738.5	114.9	10.15	73.29

Conclusion

On the basis of above review it can be concluded that sludge can be treated by gamma radiation to be very important biological organic fertilizer/soil conditioner for sustainable agriculture. It improves organic matter status of the soil. It also adds macro and micronutrients to the soil. Improvement in organic matter content in soil helps in improving soil physical conditions, rejuvenating soil health and stimulating biological activity. Higher level of soil organic matter can sequester carbon and mitigate greenhouse gas emissions. Regarding the pathogen in textile sludge, their number can be significantly reduced by radiation treatment. It can also be assumed that gamma radiation is the most attractive and favorable method of this solid waste management. It is not only managing a waste product effectively, but also presenting a way to turn into a useful product.

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